

BUMPER-II Code Updates for ISS

ORDEM 3.0

MEMCxP v2

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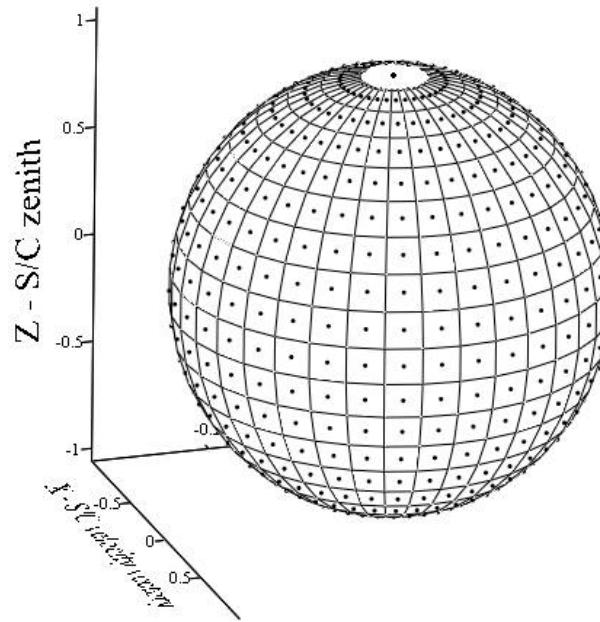
Introduction

- BUMPER-II has been updated to version 1.95j
 - Updated source code will be provided to RSC-E and Khrunichev
- New environments implemented as external data files
 - Orbital Debris: ORDEM 3.0
 - Micrometeoroid: MEMCxP v2



ORDEM 3.0: Background

- Model Populations
 - RORSAT NaK coolant droplets
 - Low-density fragments
 - Medium-density fragments and degradation/ejecta
 - Intact objects
 - High-density fragments and degradation/ejecta
- Density Bins
 - NaK = 1.0 g/cm^3
 - Low = 1.4 g/cm^3
 - Medium = 2.8 g/cm^3
 - High = 8.0 g/cm^3
- Altitude range: 100 to 40,000 km
- Time Range: 1995 to 2035
- Threats originate from $612, 10^0 \times 10^0$, patches on the sky sphere plus a north and south pole patch, for a total of 614 patches.
- The discrete closing speed distribution has 23 speed bins, from 0 to 1 km/s, 1 to 2 km/s, ... 22 to 23 km/s
- Total number of fluence integration steps for each element of analysis FEM: 614 threats x 23 speed bins = 14,122 steps.



ORDEM 3.0: Data Files (1/2)

- ORDEM 3 application produces three intermediate files
 - IGLOOFLUX_SC.OUT
 - igloo patch fluxes
 - 14,122 rows: 614 threats x 23 speeds
 - 55 columns: 11 sizes x 5 populations
 - IGLOOFLUX_SIGMAPOP_SC.OUT
 - Correlated population uncertainty estimates (for future use)
 - IGLOOFLUX_SIGMARAN_SC.OUT
 - Random uncertainty estimates (for future use)
- Files are processed by an external utility
 - >95% of the 776,710 entries in the IGLOOFLUX_SC.OUT file are zeros
 - Generate an index to the non-zero values (*.key file)
 - Compress the file by removing the zeros (*.daf file)
 - Reduces the amount of RAM required



ORDEM 3.0: Data Files (2/2)

- The final version of ORDEM 3.0 is expected to be released in mid 2012.
- NASA will provide a sample ORDEM 3.0 “.key” & “.daf” environment file for demonstration and benchmarking BUMPER-II v1.95j installation.
- After the final release, NASA will provide 27 ORDEM 3.0 output file sets at 400 km altitude & 51.6° inclination.
 - Individual years 2012 through 2035 (24 .key & .daf file sets)
 - Combined 2012 thru 2022 (current + 10yr)
 - Combined 2012 thru 2027 (current + 15yr)
 - Combined 2012 thru 2032 (current + 20yr)

ORDEM Debris flux through spacecraft 'igloo'.																					
Igloo Debris Populations Flux in Bin (no./km^2/yr)																					
Year:	2012	Elements:	14122	Populations:	55	a =	6778.136	e =	0.000000	inc =	51.60	Flux NK10	Flux NK15	Flux NK20	Flux NK25	Flux NK30	Flux NK35	Flux NK40	Flux NK45	Flux NK50	Flux NK
Element	az_low	az_high	el_low	el_high	vel_low	vel_high	Flux NK10	Flux NK15	Flux NK20	Flux NK25	Flux NK30	Flux NK35	Flux NK40	Flux NK45	Flux NK50	Flux NK					
1	-180.000	180.000	-90.000	-85.000	0.000	1.000	0.0000000E+00														
2	-180.000	180.000	-90.000	-85.000	1.000	2.000	0.0000000E+00														
3	-180.000	180.000	-90.000	-85.000	2.000	3.000	0.0000000E+00														
4	-180.000	180.000	-90.000	-85.000	3.000	4.000	0.0000000E+00														
5	-180.000	180.000	-90.000	-85.000	4.000	5.000	0.0000000E+00														
6	-180.000	180.000	-90.000	-85.000	5.000	6.000	0.0000000E+00														
7	-180.000	180.000	-90.000	-85.000	6.000	7.000	0.0000000E+00														
8	-180.000	180.000	-90.000	-85.000	7.000	8.000	0.0000000E+00														
9	-180.000	180.000	-90.000	-85.000	8.000	9.000	0.0000000E+00														
10	-180.000	180.000	-90.000	-85.000	9.000	10.000	0.0000000E+00														
11	-180.000	180.000	-90.000	-85.000	10.000	11.000	0.0000000E+00														
12	-180.000	180.000	-90.000	-85.000	11.000	12.000	0.0000000E+00														
13	-180.000	180.000	-90.000	-85.000	12.000	13.000	0.0000000E+00														
14	-180.000	180.000	-90.000	-85.000	13.000	14.000	0.0000000E+00														
15	-180.000	180.000	-90.000	-85.000	14.000	15.000	0.0000000E+00														
16	-180.000	180.000	-90.000	-85.000	15.000	16.000	0.0000000E+00														
17	-180.000	180.000	-90.000	-85.000	16.000	17.000	0.0000000E+00														
18	-180.000	180.000	-90.000	-85.000	17.000	18.000	0.0000000E+00														
19	-180.000	180.000	-90.000	-85.000	18.000	19.000	0.0000000E+00														
20	-180.000	180.000	-90.000	-85.000	19.000	20.000	0.0000000E+00														
21	-180.000	180.000	-90.000	-85.000	20.000	21.000	0.0000000E+00														
22	-180.000	180.000	-90.000	-85.000	21.000	22.000	0.0000000E+00														
23	-180.000	180.000	-90.000	-85.000	22.000	23.000	0.0000000E+00														



ORDEM 3.0: BUMPER-II Execution

- **GEOMETRY**

- Altitude and inclination prompts for ORDEM 3.0 option removed
- Execution time for ISS model with 708,392 elements \approx 6 hours
- File size \approx 1.8 GB

- **SHIELD**

- Prompts removed for the altitude, inclination, start date or duration. The altitude and inclination are implicit in the ORDEM3 “.daf” file and the start date and duration are read from the header in the “.key” file
- Prompt added for the root file name of the “.daf” and the “.key” files
- Execution time for ISS model with 708,392 elements \approx 13 minutes
- Output includes subtotals for each population:

RANGE	STARTING	ENDING	PENETRATIONS	NaK	LOW DENSITY	MEDIUM DENSITY	HIGH DENSITY	INTACTS	AREA (M ²)
1	20001	24858	0.396887E-04	0.107567E-06	0.719892E-06	0.249733E-04	0.127364E-04	0.115151E-05	180.6006077
2	20001	20500	0.195207E-05	0.510211E-38	0.268951E-07	0.141834E-05	0.385058E-06	0.121776E-06	11.6261567

MEMCxP v2: Background

- Calculates directionality of 1 microgram meteoroids
- Uses Grun flux to calculate other sizes
- Model Populations
 - Asteroids
 - Jupiter family comets
 - Short period comets
 - Long period comets
- Density = constant 1.0 g/cm³
- Threats originate from **equal area** patches (like the blocks of ice in an igloo) on the sky sphere similar to the SSP 30425 micrometeoroid threats.
 - 21 speed bins: 0 to 5 km/s, 5 to 15 km/s, 15 to 25 km/s, ... 95 to 105 km/s
 - 1,652 threat directions
 - Note: ORDEM 3.0 uses **equal angular** patches, like lines of latitude and longitude on a globe.



MEMCxP v2: Data File

Flux distributed by speed bins, speed bin labels are midpoints of speed range



MEMCxP v2: BUMPER-II Execution

- MEMCxP application produces one output file for BUMPER-II
 - Based on random draws from an input file of state vectors describing the spacecraft trajectory. (Doesn't need to be a closed orbit.)
 - Default filename: AvgMEMIglooDist.out (Igloo patch fluxes in 21 speed bins)
 - 1,652 rows (igloo patches) x 30 columns (speed bins & threat direction info)
- NASA will provide a 400 km MEMCxP v2 environment file for BUMPER-II
- GEOMETRY
 - Prompts removed for the altitude & inclination
 - Prompt added for the file name of the MEM data file
 - Execution time for ISS model with 708,392 elements ≈ 12 hours
 - File size = 4.9GB
- SHIELD
 - Prompt added for the file name of the MEM data file
 - Execution time for ISS model with 708,392 elements ≈ 5 minutes



BUMPER-II Run Time Comparison

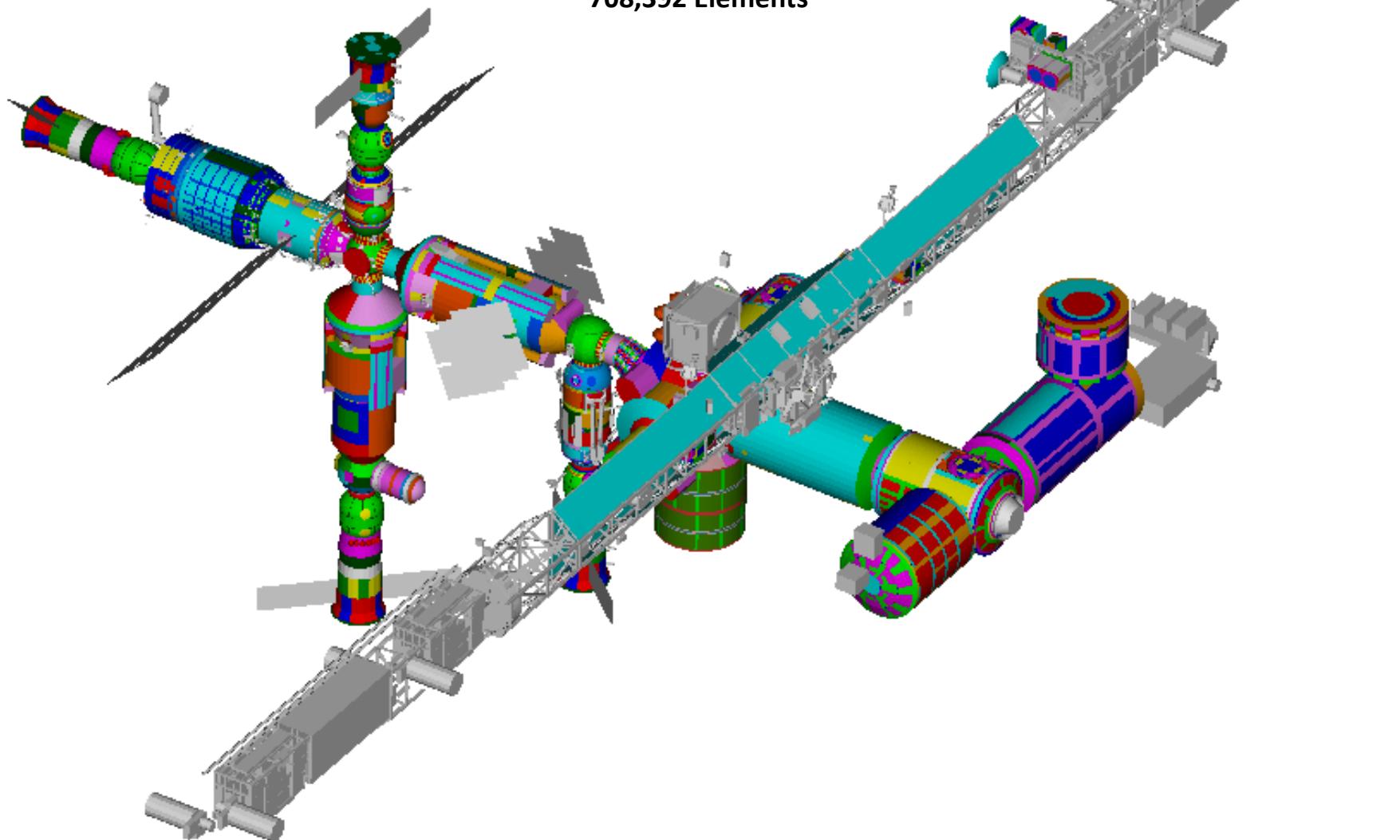
Environment	Threats	Geometry (min)	Shield (min)
OD2k	90	34	11
OD3	614	360	13
MEMCxP v2	1652	720	5

- Code: BUMPER-ISS v1.95j
 - Uses ASCII formatted OD3 input files (not binary)
 - 32 bit build using Intel FORTRAN compiler v10.1.013
- Hardware: Dell Precision T7500
 - Dual Quad Core Xeon E5530 (2.4GHz) w/12GB RAM
 - Windows XP Professional 64bit
- Model: ITA12-Stage2014,2-revE-FIN.unv
 - 708,392 elements
 - Run times based on 3 concurrent single threading Perl scripts



ITA-12 Stage 2014-2

905 Property IDs
708,392 Elements



09-Jan-12

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